

Notice of Allowability

Application No.

10/659,136

Examiner

Jennifer M. Dolan

Applicant(s)

STOJAKOVIC ET AL.

Art Unit

2813

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to Election, filed 4/6/05.
2. ☒ The allowed claim(s) is/are 14-42.
3. ☒ The drawings filed on 10 September 2003 are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 - a) ☐ All b) ☐ Some* c) ☐ None of the:
 1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.

THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
 6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
 - (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
 - 1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
 - (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.
- Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08),
Paper No./Mail Date 9/10/03; 9/26/03
4. ☐ Examiner's Comment Regarding Requirement for Deposit
of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413),
Paper No./Mail Date _____.
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

DETAILED ACTION

Election/Restrictions

1. Applicant's election of Group IV, claims 14-42, in the reply filed on 4/6/05 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)).
2. This application is in condition for allowance except for the presence of claims 1-13 and 43-58 to inventions non-elected without traverse. Accordingly, claims 1-13 and 43-58 have been cancelled.
3. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The application has been amended as follows:

Claims 1-13 and 43-58 have been cancelled.

Allowable Subject Matter

4. Claims 14-42 are allowed.

5. The following is an examiner's statement of reasons for allowance:

The primary reason for allowance is the inclusion of several method steps not suggested by the prior art. Claim 14 requires a tantalum nitride layer over an MTJ stack, a titanium layer over the TaN layer, and a titanium nitride layer over the Ti layer, where these three layers are etched by a specific sequence of etching steps.

The prior art does provide suggestion of three-layer metal hardmasks, such as in US 2004/0188732 to Fukuzumi, which teaches a lamination of Ta/Al/Ta for the hardmask layer, US 2004/0014245 to Motoyoshi, which teaches a (TiN or TaN/Ta or TaN/SiN) mask structure, or US 6,806,096 to Kim et al., which suggests that any combination of TaN, TiN, Ta, or similar metals may be layered to form a hardmask. These prior art hardmasks, however, do not follow the same etching sequence as set forth in claim 14, but rather either the entire hardmask is etched in a single step, or each etching step completely removes one layer of the hardmask. Other prior art references teach a bilayer hardmask made of similar materials as the claimed invention, such as US 6,518,588 to Parkin et al., US 2003/0206434 to Leuschner, US 6,707,084 to Katti et al. Since the bottom layer is identified as an etch stop, it can be assumed that two separate etching steps are used to pattern the hardmask layer.

The claimed invention, however, significantly builds upon these prior art masking structures and methods, by using a TiN/Ti/TaN hardmask laminate, where a first etching step etches a majority of the top TiN layer, a second etching step etches through the remainder of the

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TiN layer and part of the Ti layer, and a third etching step etches through substantially the remainder of the hardmask stack. This series of method steps provides significant improvements over the prior art by allowing for highly vertical sidewalls in the first etch, allowing for sufficient selectivity in the second etch to ensure that the TaN hardmask layer is not completely etched through. This specific sequence ensures that the photoresist can be removed before exposing the MTJ stack layers, in order to eliminate problems with photoresist fencing, and it ensures that a good barrier layer, such as TaN may be used overlying the MTJ stack to prevent diffusion of metals from the MTJ stack.

Since these claimed features are not suggested by the prior art, and since they provide specific improvements for masking and etching an MTJ stack, it is the Examiner's opinion that the subject matter of claim 14 is well beyond the purview of a person having ordinary skill in the art and is well beyond the scope of the prior art of record.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

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- a. U.S. Patent No. 6,806,096 to Kim et al. discloses the use of a hardmask comprising TaN, TiN, Ta, or any combination thereof over an MTJ stack, and a step of depositing a sidewall oxide on the patterned hardmask before etching the tunnel layer and pinned layers of the MTJ.
- b. U.S. Patent Publication No. 2004/0188732 to Fukuzumi discloses a Ta/Al/Ta hardmask over an MTJ structure, where an AIO spacer is deposited on the sidewalls of the hardmask and free layer before etching the remainder of the MTJ stack.
- c. U.S. Patent Publication No. 2004/0014245 to Motoyoshi discloses a three layer hardmask, wherein the top layer is SiN, and wherein the photoresist is removed after the entire hardmask is etched.
- d. U.S. Patent No. 6,689,622 to Drewes, U.S. Patent No. 6,707,084 to Katti et al., U.S. Patent Publication No 2003/0206434 to Leuschner, and U.S. Patent No. 6,518,588 to Parkin et al. disclose bilayer hardmasks using Ta, Ti, W, and nitrides thereof, and wherein the bottom layer of the mask is used as an etch stop
- e. U.S. Patent No. 6,897,532 to Schwarz et al. discloses providing oxide spacers on the sidewalls of the hardmask and free layers before etching the remainder of the MTJ stack.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Jennifer M. Dolan whose telephone number is (571) 272-1690. The examiner can normally be reached on Monday-Friday 8:30am-5:00pm.

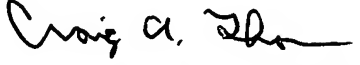
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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl W. Whitehead, Jr. can be reached on (571) 272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Jennifer M. Dolan
Examiner
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jmd


CRAIG A. THOMPSON
PRIMARY EXAMINER